Assessing Phosphorus Reduction Co-Benefits of Watershed Restoration Projects

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Bryce Carleton, Sarah Clauss, Tucker Diveley, Jenna Goodman, Erica Hirschhorn, Charlotte O'Brien, and Lindsay VanFossen

In partnership with the Vermont Department of Environmental Conservation (Chris Rottler, Ethan Swift, and Ben Copans)

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Abstract

This project aims to promote awareness of co-benefits regarding phosphorus (P) total maximum daily load (TMDL) reduction in Vermont water bodies under Act 76, which supports projects that address Vermont's clean water goals. The purpose of this document is to aid Basin Water Quality Councils in assessing P removal project proposals. Many studies have demonstrated how P runoff greatly contributes to eutrophication, causing cascading environmental consequences in the watershed. Eutrophication negatively impacts water bodies and prevents them from being a safe drinking source, an accessible place for recreation, and a healthy habitat for aquatic organisms. In recent years, there has been an increasing awareness of the co-benefits associated with reducing P inputs to water bodies. Drafting an extensive list of environmental, social, and economic co-benefits identified areas of concern, which were then refined into a more user-friendly list of categories. Each co-benefit was supplemented by an informative paragraph citing relevant literature to provide context. Qualitative and/or quantitative metrics were assigned to help councils assess whether a project addressed the listed co-benefits. For ease of use, a one page checklist was also created and tested to increase the efficiency of the review process for project proposals. This document will aid councils in differentiating between the numerous project proposals that may be equal in P reduction potential. The future of this document requires more involvement of stakeholders, especially those of vulnerable communities, and more testing using real world project proposals.

Introduction

Phosphorus pollution in Vermont watersheds is an issue of increasing importance and relevance. Phosphorus (P), in small quantities, serves as a vital nutrient in soil composition. It is constantly recycled through plant uptake, weathering and erosion into our water bodies, and back into our sediments as dissolved phosphates. However, intensified and unsustainable agricultural practices, deforestation, and impervious surfaces in urban environments have altered this natural cycle and intensified the amount of phosphorus that reaches streams, rivers, and lakes. A majority of phosphorus runoff comes from nonpoint sources (encompassing multiple locations across a broad geographic range), which makes it difficult to identify and mitigate. If high inputs of nutrients like P run into surface waters, dense algal blooms may occur, leading to eutrophication. This impairment of water bodies has far-reaching environmental, social, and economic consequences for Vermont communities.

Targeting the sources of phosphorus runoff would reduce this impairment of water bodies. However, it is difficult to identify sources and mass cooperation is usually required for phosphorus reduction. By engineering or restoring ecosystems in areas between the source of runoff and surface waters, the P-loaded runoff can be caught and treated through natural processes before entering the body of water. In addition, phosphorus removal projects are often associated with many other environmental, social, and economic benefits, such as increasing recreational opportunities, improving ecosystem health, or providing more equitable access to clean water. These additional advantages, often referred to as co-benefits, are the main focus of this assessment tool.

The Clean Water Service Delivery Act of 2019 (Act 76) supports projects that address Vermont's clean water goals. The act is specifically focused on the total maximum daily loads (TMDLs) for P in the Lake Champlain and Lake Memphremagog basins, which are limitations on the total amount of phosphorus that can enter these bodies of water (State of Vermont, 2021). Through Act 76, the Vermont Department of Environmental Conservation provides funding for P removal and mitigation projects, with a specific focus on reducing inputs from nonpoint sources.

Proposals will be assessed by the Basin Water Quality Councils (BWQC) based on P removal and mitigation potential. P is the only nutrient that has TMDL guidelines, which makes it a priority for water quality improvement projects. However, as discussed above, there are many co-benefits associated with these initiatives which, while they may not be a direct focus of phosphorus removal projects, are extremely important for Vermont's natural and social

communities. The DEC is looking to create general guidance for assessing how projects address these co-benefits.

User's Guide/How to Use This Document

This manual is intended to act as a guide for Basin Water Quality Councils (BWQC) and Clean Water Service Providers (CWSP) to use when assessing project proposals. It is based on twenty-four specific co-benefits spanning the themes of Environmental Justice, Clean Water and Sanitation, Ecosystem Services and Climate Resiliency, Recreation and Community, Education, and Economic Growth.

There is a short checklist that contains the six broad themes with short descriptions of each theme. This is formatted as a yes/no checklist so BWQC can quickly determine which co-benefits apply to a project proposal and which co-benefits do not. If more details are needed to decide on a project, BWQC can then refer to the more extensive lists in the "Co-Benefits Metrics" and the "Co-Benefits Descriptions" sections.

In the "Co-Benefits Metrics" section, specific co-benefits and their corresponding metrics are listed by thematic category. This section is formatted as a worksheet to help BWQC efficiently note the extent to which each co-benefit fulfills its respective metrics. The number of metric questions answered identifies which co-benefits a proposal includes. Please note that not all metric questions may be applicable, particularly for early stage projects.

The "Co-Benefits Descriptions" section explains and defines each category's co-benefits in more detail, using a variety of sources to provide evidence-based guidance. These sections should give BWQC more information about why each co-benefit is important and how they can be incorporated in projects. Included in each section is an example of the minimum needed for a project to be considered for said co-benefit.

The Appendices contain a condensed list of co-benefits, a map of Vermont's socially vulnerable areas, and a spreadsheet comparing these areas with the location of 303(d) Impaired Waters. The map and the spreadsheet primarily correspond with the Environmental Justice metrics.

Matrix

Project Title: _____

1. Environmental Justice		
This project prioritizes vulnerable areas (refer to Appendix 1) and engages their community members and stakeholders. Access to clean water and food, acknowledging land stewardship, sacred resources, and Indigenous property are environmental justice issues that could be considered.	☐ Yes	☐ No
2. Clean Water and Sanitation		
This project directly addresses reduction of key pollutants other than phosphorus. These can include, but are not limited to: Nitrogen, sediments, road salts, heavy metals, microplastics, pathogens or other contaminants of emerging concern.	☐ Yes	☐ No
3. Ecosystem Services and Climate Resiliency		
This project addresses the co-benefits related to ecosystem services and climate resiliency that may come with reducing phosphorus. Ecosystem services include carbon sequestering, flood resiliency, reducing erosion, promoting pollinators and native species, and biodiversity.	☐ Yes	☐ No
4. Recreation and Community		
This project addresses the ways that outdoor space positively affects the community through access to recreational activities, more outdoor spaces, or increasing tree canopy.	☐ Yes	☐ No
5. Education		
This project includes aspects of public outreach designed to educate community members about the importance of phosphorus reduction and watershed health and/or involve community members in project development and implementation. This may include interpretive signage, educational series/workshops, making project development meetings open to the public, and/or classroom work.	☐ Yes	☐ No
6. Economic Growth		
This project specifically addresses cost-efficient and sustainable economic growth through strategies such as workforce development, sustainable energy practices, green stormwater infrastructure, and increased property values.	☐ Yes	☐ No

Notes:

Co-Benefits Metrics

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1. Environmental Justice

1.1 Prioritizing Vulnerable Communities: Vulnerable communities may be defined as those towns which rank on the Vermont Social Vulnerability Index, AND house 303(d) impaired waters.

A. Is the project located in a town(s) with an SVI ranking?* **Yes / No**
B. How many SVI flags does this town have?* **# of Flags:_____**
   More flags = higher ranking
C. Are 303(d) impaired waters present in this area(s)?* **Yes / No**
D. Will the proposed project benefit the/these SVI area(s)? **Yes / No**
   If yes to any of the above questions, rank higher

**See Appendix B and C*

1.2 Involvement of Community Stakeholders: Those impacted by the project and have an effect outside the project's parameters.

A. What groups or people are impacted by the project or have an effect on the project? (who should have an effect?)
   - Primary:
   - Secondary:
   - Key:
B. Will these groups be made aware of the project? **Yes / No**
   The more community involvement, higher priority

1.3 Honoring Traditional Ecological Knowledge: Traditional ecological knowledge is a process of multi-generational environmental and ecological knowledge held by Indigenous communities, through their repeated interaction with the land.

A. Does the project use traditional ecological knowledge? **Yes/No**
   If yes, rank higher

1.4 Access to Clean Water and Food: All people should have access to clean drinking water and the quality of water is free from harmful bacteria, germs, suspended impurities and salts. It is clear, colorless and odourless.

A. Does the project impact drinking water? **Yes / No**
B. Groundwater or surface water? **Ground / Surface**
C. Is the project located in a low income community? **Yes / No**

If yes, identify water quality and purification facilities to assess filtration process and quality of water

D. Is the community located near a waste treatment facility? **Yes / No**
If yes, assume those around the facility are impacted by the facility and prioritize this project

1.5 Protecting Sacred Resources and Indigenous Land: These are areas registered by Indigenous communities, recognized as sacred by a religious group, or pertain to religious ceremonies, regardless of official Vermont State recognition.

A. Is the land private or public? **Private / Public**
If **Private:** Does the proposal include an equitable plan to collaborate with landowners? **Yes / No**
If **Public:** Does the proposal include an equitable plan to collaborate with local Indigenous communities? **Yes / No**
B. Does land have historical Indigenous significance? **Yes / No**

2. Clean Water and Sanitation

2.1 Reduction/Treatment of Other Key Pollutants:

- Nitrogen
- Sediments
- Road salts
- Microplastics / plastics
- Heavy Metals
- Pathogens
- Sewage / wastewater
- Contaminants of emerging concern

A. Are any of these pollutants of concern in the project area? **If Yes, which ones?**
B. Are their presence or their treatment quantifiable? **Yes / No**
C. If yes, what are the daily loads treated (pollutants removed from the water before reaching surface waters) / prevented (source of pollutants targeted)?
Concentration = _____/L of water

3. Ecosystem Services and Climate Resiliency

3.1 Carbon Sequestration: Viable climate change mitigation strategy which can reduce atmospheric CO2 as well as greenhouse gas effects.

A. Does the project include this? **Yes / No**
B. If yes, is it quantifiable? **Yes / No**
C. If yes, how many metric tonnes are stored? _____ **mt**
D. How many acres of trees will be planted? _____ **acre(s)**

3.2 Flood Resiliency and Reduction: Provides lower risk to communities and infrastructure by restoring the water body to natural flow patterns and restoring floodplains and riverbanks.

A. Is this included in the proposal? **Yes / No**
B. If yes, is this an area where flooding is a current concern or projected to be a concern in the future? **Yes / No**
C. If yes, is it quantifiable? **Yes / No**
D. Is the entire river/stream being restored or only a section? **Entirety or Section**
E. How many acres/miles of floodplain are being restored? _____ **mi/acres**

3.3 Reduced Runoff and Erosion: Includes management practices that increase aggregation and infiltration as well as implementation of permeable surfaces.

A. Is this included in the project? **Yes / No**
B. If yes, can it be quantified? **Yes / No**
C. If yes, how many acres of surface will the project be influencing? _____ **acres**
D. Is this area large enough to reduce the majority of runoff being produced (i.e. larger than a household garden, implementation on an entire farm, etc.)? **Yes / No**
E. Will the project be targeting the source of the runoff? **Yes / No**

3.4 Supporting Native Pollinator Species: Includes planting native flora, avoiding pesticides that harm native species, and introducing plant species that promote native pollinators.

A. Is this included in your proposal? **Yes / No**
B. If yes, can you quantify it? **Yes / No**
C. How many native plant species will be introduced? _____ **native plant species**
D. How many pollinator promoting species will be planted? _____ **pollinator promoting species**
E. How many native pollinators is this projected to influence? **[List Species:]**
F. Will any double flowers be planted? **Yes / No**
G. Is the area at least 0.5 - 2 acres? _____ **Yes / No**

3.5 Promoting Biodiversity: Promotes the importance of aquatic biodiversity growth when boosting resiliency in a floodplain and provides types of native species to include if biodiversity is low.

A. Is biodiversity addressed in the proposal? **Yes / No**
B. Is the proposed area known for high biodiversity or low? **High / Low**
C. How many species do you plan on including if needed to support low biodiversity levels? **[List Species:]**

3.6 Reduction of Aquatic Invasive Species (AIS): Reducing Vermont's high priority AIS's is crucial to protecting native species and restoring the ecosystem.

A. Are there high priority invasive species that are a concern on the project site?

Yes / No

B. Are you able to quantify the amount removed? **Yes / No**

3.7 Improving Terrestrial and Aquatic Habitat Connectivity: Includes the effect that man-made systems have on habitat fragmentation and the resulting conservation statuses of species or populations.

A. Are there different land usages in your project area that lead to higher fragmentation? **Yes / No**
B. If yes to 3.7.A (above), is there a plan to repair habitat connectivity if the project site has suffered from habitat fragmentation? *See VT ANR Biofinder
C. Are there endangered or threatened species in the project area? **Yes / No**

3.8 Addressing High Risk Areas Due to Past Environmental Degradation: Includes high risk communities that are environmentally and socially vulnerable.

A. Have there been past pollution events in this proposed area? **Yes / No**
B. Is this a socially vulnerable area? **Yes / No**

4. Recreation and Community

4.1 Inclusive Accessibility of Natural Areas for Local Communities: Maximizes accessibility into a full range of recreational activities while still protecting and maintaining natural resources

A. Does the project propose an accessible space? **Yes / No**
B. If yes, **Area of Accessible land:_____**

4.2 Aesthetics & Green Space (Mental Health Benefits): Interactions with nature promote psychological restoration, improve mood, improve attention, and reduce stress and anxiety

A. Does the project increase aesthetics and green space? **Yes / No**
B. If yes, **Number of plants/trees planted:_____**

4.3 Increasing Outdoor Recreation Opportunities: Adding new recreational opportunities such as new hiking trails and campsites, as well as improving and maintaining existing recreational sites

A. Are recreational areas included in the project? **Yes / No**
B. Does the project add new recreational spaces?
Number/area of recreational spaces added:_____
C. Does the project maintain current recreational spaces?
Area of recreational space maintained _____

4.4 Increasing Urban Tree Canopy: Urban tree canopy is defined as the branches and leaves that cover the ground when viewed from above.

A. Does the project increase urban tree canopy? **Yes / No**
B. If yes, are they utilizing native tree species? **Yes / No**

C. **Number of trees planted:_____**

5. Education

5.1 Watershed Education and Awareness of Environmental Problems: Watershed education builds awareness of environmental problems through a lens of systems thinking.

A. Is this included in the proposal? **Yes / No**
B. If yes, is it quantifiable? **Yes / No**
C. Roughly how many people will be reached by the proposed education initiative? **_____ people**
D. Is it passive (like signage) or active (like workshops)? **Passive/Active**

5.2 Trust Between Communities, Scientists, and Agencies: Meaningful involvement of community members builds relationships, empowers communities, and strengthens projects.

A. Is this included in the proposal? **Yes / No**
B. If yes, will data collected by community members be used to inform management practices? **Yes / No**
C. Are there efforts to meaningfully engage community members in decision-making processes? **Yes / No**

6. Economic Growth

6.1 Job Creation, Retention, and Workforce Development: Creating and upgrading sustainable infrastructure creates jobs in the construction and wastewater sectors.

A. Are jobs being created by the proposal? **Yes / No**
   If yes, is it quantifiable? **Yes / No**
B. How many jobs are being created by the proposed action? **_____ jobs**
C. Are the jobs being created temporary or permanent? **Temporary / Permanent**
D. Is subsidized education and job training included? **Yes / No**
E. Is there potential for career advancement? **Yes / No**
F. Is unemployment a concern in this area? **Yes / No**

6.2 Promote Sustainable Energy Practices: Sustainable energy practices can be promoted by using renewable energy sources and improving energy efficiency in drinking water and wastewater plants.

A. Is this included in the proposal? **Yes / No**
   If yes, is it quantifiable? **Yes / No**
B. If yes, how much energy is being saved by the energy efficiency practice(s) being implemented? **_____ kWH**

C. Is a renewable energy source being used? **Yes / No**

6.3 Carbon Reduction via Green Stormwater Infrastructure: Includes the sustainable value of green infrastructure and how to use a cost-benefit analysis to measure the proposed infrastructure design.

A. Is there a plan to develop green stormwater infrastructure? **Yes / No**
B. Is there a cost benefit analysis for this infrastructure? **Yes / No**

6.4 Increased Property Values: Improvements in water quality, particularly those reducing cyanobacterial blooms, are associated with higher property values in waterfront homes.

A. Is this included in the proposal? **Yes / No**
B. How many properties are contained within the watershed in question? **____ properties**
C. What is the average property value for a house in this area? **_____ USD**

Additional Co-benefits Information

1. Environmental Justice

1.1 Prioritizing Vulnerable Communities:
To be considered for the "Prioritizing Vulnerable Communities" co-benefit, the project must directly benefit a community which ranks on the Vermont Social Vulnerability Index (SVI). The SVI "is a planning tool to evaluate the relative social vulnerability across the state…The SVI draws together 16 different measures of vulnerability [1 flag = 1 measure of vulnerability] in three different themes: socioeconomic, demographic, and housing/transportation," (Vermont Department of Health, 2015). SVI vulnerability measures overlap with environmental justice concepts, in particular those of race and economic class (American Public Health Association, n.d.). Because marginalized communities are disproportionately affected by environmental degradation, water quality project proposals involving waters and/or watersheds should be highly ranked.

1.2 Involvement of Community Stakeholders:
Stakeholders have an impact on a project or make efforts in moving projects forward. Primary stakeholders are groups directly affected by the project. These people should have the most input in regards to the direction of the project (be mindful of conflict between primary stakeholders), according to research conducted by Rabinowitz. Secondary stakeholders are those who are indirectly affected and should weigh in, but the project often will not be able to satisfy all their needs (Rabinowitz 2021). Lastly, key stakeholders are crucial in bringing the project to pass (Rabinowitz 2021). This includes leaders of organizations and workers who implement the project. For a project to be considered for the Involvement of Community Stakeholders co-benefit, it must be fair to everyone involved, including varied perspectives from all sectors of the community, with an emphasis on minority communities, and create social capital or active participation of citizens in public affairs.

1.3 Honoring Traditional Ecological Knowledge:
Traditional ecological knowledge (TEK) is a multi-generational process of knowing (Berkes, 2009). This knowledge is learned over the course of tens of thousands of years by Indigenous communities, through their repeated interaction with the land (Berkes, 2009; Vinyeta and Lynn, 2013). Multiple publications advocate for the use of TEK in natural resource management as an invaluable social and ecological approach (Berkes, 2009; Vinyeta and Lynn, 2013; Zedler and Stevens, 2018). Additionally, because TEK requires collaboration with Indigenous communities, utilizing a TEK approach in any form has positive environmental justice implications. To be

considered for the “Honoring Traditional Ecological Knowledge” co-benefit, a project proposal must clearly outline how, and in what capacity TEK will be used.

1.4 Access to Clean Water and Food:

Race and socio-economic status matter in the distribution of environmental burdens. Toxic waste sites and facilities are more likely to be sited in low-income neighborhoods, with primarily nonwhite residents (Bullard et al. 2007; Fricker and Hengarten 2001; Rowan and Fridgen 2000). “The federal Safe Drinking Water Act requires all drinking water to meet health standards set by the EPA, but violations occur regularly. In one year alone, nearly one-third of all people drinking water from a public system had a health violation” (EPA 2009). Many problems come from agriculture-related contamination to water sources. It’s important to be mindful, when projects deal with agriculture, to preserve local food sources and ensure equitable access. The distribution of food is still the primary cause of inequitable access to affordable nutritious food. For a project to be considered for the Access to Clean Water and Food co-benefit, it must include a plan to reduce agricultural runoff into waterways (especially in areas of high social vulnerability), water quality assessments before and after project implementations, and involvement through every step of the project including monitoring after completion of project.

1.5 Protecting Sacred Resources and Indigenous Land:

Colonial violence has been well documented in the Americas. Positioned on unceded Abenaki, Wabanaki, Mohican, and Penacook territory, this brutality is part of Vermont's history (https://native-land.ca/; USDA Forest Service). These Indigenous groups have lived on and with the land for at least ten thousand years. Multiple areas in Vermont, such as the Brunswick Springs in the Northeast Kingdom and parts of the Green Mountains, hold historical and spiritual significance to local Indigenous communities (USDA Forest Service). To be considered for the “Protecting Sacred Resources and Indigenous Land” co-benefit, a project proposal must include a prior land usage analysis to determine what Indigenous cultural significance the area holds, and if the area is considered sacred to any Indigenous group. A documented plan to involve Indigenous communities affected and adhere to their suggestions is also required.

2. Clean Water and Sanitation

2.1 Reduction/Treatment of Other Key Pollutants:

Many projects designed to reduce Phosphorus loads into bodies of freshwater have the ability to treat multiple other pollutants that are also cause for concern but do not have Total Maximum Daily Loads (TMDL)[1]. Below are their impacts. For a project to be considered for the Reduction/Treatment of Other Key Pollutants co-benefit, it must reduce daily loads of any of the below or other pollutants.

Nitrogen has been researched and shown to be a prevalent pollutant in surface waters and is also a bioavailable nutrient responsible for eutrophication (Howarth and Marino, 2006; Hurley et al., 2017).
Sediments (suspended solids) are prevalent pollutants and can result in high turbidity in water bodies . High turbidity decreases the amount of sunlight in the water, and negatively affects ecosystem health by way of vegetation and algal growth disruption (Sea Grant).
Road Salts reaching water bodies can negatively impact organisms in these systems who are not salt tolerant and decrease concentration of dissolved oxygen (Sea Grant).
Microplastics have been shown to obstruct digestive systems in fish while absorbing and trapping toxic chemicals (Journal of Great Lakes Research). This can lead to impairment of ecosystems and human health if the affected species are a food source.
Heavy metals, pathogens, and wastewater/sewage can all negatively impact human health and even lead to death, for users of affected water. Note that a project does not need to directly treat sewage and wastewater. Many towns/cities have a combined storm and wastewater piping system where, in cases of high surges of stormwater, the treatment centers suffer intense inputs. In cases like these, both storm and wastewater are untreated and drained into the lake resulting in further impairment (DEC, 2017).
Contaminants of Emerging Concern is a category of new contaminants which have not been explored as in depth as those above and can cause impacts on both environmental and human health. Examples of these are: Herbicides/pesticides, livestock antibiotics, pharmaceuticals, cleaning products, and other unknown pollutants (USFW, 2020).

[1] Total Maximum Daily Loads (TMDL): "The calculation of the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for that particular pollutant" (EPA, 2021).

3. Ecosystem Services and Climate Resiliency

3.1 Carbon Sequestration:
Carbon sequestration "secures carbon dioxide (CO2) to prevent it from entering the earth's atmosphere" (UC Davis, 2021). This ecosystem service can be offered by various ecosystems, however, it is primarily supplied by forests (Buotte et al., 2019). Forests can store immense amounts of carbon, however, "the US Forest Survey estimates that privately owned forestland stores 77.1 metric tonnes of carbon per acre, while public forestland stores 81.6 to 84.6 Mt/A" (VT Dept. of Forests, Parks, & Recreation, 2016). Vermont tree species that store the most carbon can include sugar maple, red oak, beech, red maple, birch, white ash, black cherry, and others (VT Dept. of Forests, Parks, & Recreation, 2016). The diameter of the tree also matters. Trees with a diameter of at least 60 cm (23.6") will store more carbon than those with smaller diameters (VT Dept. of Forests, Parks, & Recreation, 2016). For a project to be considered for the Carbon Sequestration co-benefit, the forest area must be at least one acre and include native

trees or those that store the most carbon. In addition, projects must have plans for longterm forest growth and conservation, especially when planting young trees. Refer to the Forest Carbon document located at the Vermont Department of Forests, Parks, and Recreation's website for more information.

3.2 Flood Resiliency and Reduction:

Flood resiliency and river restoration will become increasingly important as climate change persists. Restoring these water bodies to their natural flow patterns and adding bank stabilization will provide safety for surrounding ecosystems, human communities, and infrastructure. To implement restoration, it is necessary to have "clearly identified objectives, holistic understanding of rivers as ecosystems, and the role of restoration as a social process" (Wohl et al., 2015). For a project to be considered for the Flood Resiliency co-benefit, the project must be in an area where flooding is a current or projected problem due to climate change, and the area must be a large enough section to successfully reduce flooding. Ways to promote river restoration include introducing buffer zones, wetlands, floodplains, and bank stabilization, especially in areas at risk of flood damage.

3.3 Reduced Runoff and Erosion:

Erosion reduction methods can include erosion control blankets, reducing tillage, avoiding soil compaction, rotating crops, and using soil that allows for good infiltration (VT DEC, 2019). Ways to prevent soil compaction can include "using wider tires or dual tires, avoiding use of heavy machinery, avoiding tillage of wet soils, and reducing the amount of times the field is passed over" (University of Illinois, 1997). Another way to reduce runoff is planting native trees adjacent to river banks. However, the most "economic and effective way to promote erosion control is the diversion of surface water away from exposed soils" (VT DEC, 2019). This means targeting the runoff at the source. Permeable surfaces are made of materials that allow water to infiltrate into the surface and reduce the amount of runoff during a storm event. Examples of permeable surfaces can include: "permeable pavement in roads or sidewalks, gravel, sand, turf grass, recycled plastic, etc." (Un, 2010). When implementing permeable surfaces, it is necessary to know the geography of the project area (slope of the land, depth of frost penetration, etc.) (Kimchi, 2015). In order for a project to be considered for the Reduced Runoff and Erosion co-benefit, the project must contain an area large enough to effectively prevent erosion or runoff and/or target the runoff at the source. Refer to The Vermont Standards and Specifications for Erosion Prevention & Sediment Control for exact measurements of effective acreage. For more information regarding permeable paving, refer to the Metropolitan Area Planning Council "Fact Sheet: Permeable Paving" website:
https://www.mapc.org/resource-library/fact-sheet-permeable-paving/

3.4 Supporting Native Pollinator Species:

Native pollinators keep our ecosystems stable by helping plants reproduce, maintaining food and habitat for many organisms. Studies have shown that "native pollinators are responsible for bringing us one out of every three bites of food" (Pollinator Partnership, n.d.). According to the Natural Resources Conservation Service, it's suggested that pollinator gardens need to be an area of 0.5 - 2 acres in order for the beneficial insectaries and habitat to be present (NRCS, 2013). It's necessary to use a wide variety of plants that bloom from early spring to late fall, avoid modern hybrid flowers especially "double" flowers, eliminate pesticides, include larval host plants, create a damp salt lick for butterflies and bees, and add a hummingbird feeder (US Forest Service, n.d.). Other important variables the US Forest Service states to consider when designing a pollinator garden includes choosing at least 20 different types of plants to support biodiversity and including night blooming flowers to attract moths and bats which also serve important ecosystem niches (US Forest Service, n.d.). Pollinators have evolved with native plants so it is necessary to find plants native to Vermont. For a project to be considered for the Supporting Native Pollinator Species co-benefit, it must have a land plot size greater than 0.5 acres, have at least 20 different types of plants, consist of plants that are native and/or attract pollinator species, and exclude plants with double flowers.

3.5 Promoting Biodiversity

Biodiversity is an important tool to measure ecosystems. Species abundance is a main indicator of how biodiverse the region is (Babu, 2020). Restoring diversity to a higher level increases ecosystem resilience. Resiliency is defined by how easily the ecosystem can bounce back and recover after a disturbance, whether that be a natural disaster or an engineering/manmade project. Lower levels are associated with a weaker ecosystem that is more vulnerable to environmental and human harm. This is why biodiversity is an important benefit to watershed restoration projects. Projects should emphasize promoting biodiversity in floodplains because these areas are hotspots for terrestrial and aquatic species abundance. Planting native species can contribute to the diversity. Vermont's native aquatic species include Pickerelweed, Broadleaf cattail, Duck potato, and White water lily, to name a few (Wettergreen, 2021). Keystone species are also very important to protect as they are biodiversity indicators (Babu, 2020). For a project to be considered for the Promoting Biodiversity co-benefit, it must aim to protect terrestrial and aquatic species and contribute actions that support rather than inhibit biodiversity.

3.6 Reduction of Aquatic Invasive Species (AIS)

The VT DEC Watershed Management division defines an Aquatic Invasive Species (AIS) as an organism that has been introduced to a new ecosystem that is outside of the organism's natural range (VT DEC, 2021). Invasives efficiently exploit ecosystem processes which negatively impact native species. The National Wildlife Refuge System divides removal methods into physical, biological, and chemical. The spatial scale and severity of the specie's spread across a landscape influences the type of removal method (National Wildlife Federation, 2021). For example, a backyard patch of garlic mustard can be tackled by physical hand pulling while

machinery might be needed to harvest a large scale patch of water chestnut. Invasives are skilled at hitchhiking from one water body to another via sticking to an aquatic vehicle. An easy way to stop these hitchhikers is to thoroughly wash down the vehicle after use. A fine of $1,000 has already been implemented and targeted towards aquatic vehicle owners which creates an economic incentive to be more responsible and aware of AIS. For a project to be considered for the Reduction of Aquatic Invasive Species co-benefit, it should address the high priority species and their respective removal methods while taking into account the spatial and severity scale of the spread. Other invasives not listed as high priority, but are deemed important in restoring the landscape should be also addressed.
According to the VT DEC, these invasives are high priority in Vermont watersheds (UVM Extension, n.d.):

- Water chestnut
- Eurasion milfoil
- Zebra mussels
- Hydrilla
- Starry stonewort
- Curly-leaf pondweed
- Variable Leaf watermilfoil
- Spiny waterflea
- Asian clam
- Rusty crayfish
- Didymo
- Alewife

3.7 Improving Terrestrial and Aquatic Habitat Connectivity

The National Wildlife Federation describes habitat connectivity as the degree to which a landscape supports or prevents natural wildlife movement (National Wildlife Federation, 2021). Habitat fragmentation occurs when manmade systems, such as grey infrastructure, fragment the landscape. This can have a severe effect on the species's population conservation status. The IUCN lists nine different categories: Not Evaluated, Data Deficient, Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild and Extinct (International Union for Conservation of Nature and Natural Resources, 2021). It is crucial to biodiversity health to understand the natural flow of both terrestrial and aquatic species and their population status in the project area. For a project to be considered for the Improving Terrestrial and Aquatic Habitat Connectivity co-benefit, it must address the conservation status of the species and the current fragmented state of the species's habitat. If appropriate, the project should consider and outline strategies to improve wildlife corridors through natural infrastructure such as constructed wetlands or riparian buffers. To help with this see VT's Agency of Natural Resources, BioFinder tool which highlights corridors that link habitats together to improve connectivity: https://anrmaps.vermont.gov/websites/BioFinder/

3.8 Addressing High Risk Areas Due to Past Environmental Degradation

High risk areas are important to acknowledge and include in a project restoration plan. These areas can be the first steps in mitigating disaster events in socially vulnerable communities. The Pine Canal Superfund site is an example of a high risk area. This area has already experienced environmental racism and harm. Toxic chemicals were disposed of in the Pine Street Canal Wetland that posed ecosystem harm to the local species. Concern with toxic leakage into Lake Champlain and potential harm to the drinking water supply as well as the aquatic ecosystem. Groundwater is no longer viable as a drinking water supply due to coal tar leakage. (Environmental Protection Agency, 2017). For a project to be considered for the Addressing High Risk Areas co-benefit, it must consider if the project area is a high risk site. If it is, then the project should address a holistic approach towards working with the site's environment and community.

4. Recreation and Community

4.1 Inclusive Accessibility of Natural Areas for Local Communities:

In the 2010 Census, about 1 in 5 people in America had a significant disability that led to major limitations in physical activities such as walking. People with disabilities make up the largest minority in the country. If one person in a recreating group has a disability, it makes accessibility an issue for the entire group. The goal should be to get as many people as possible outside enjoying and benefiting from nature. Having accessible trails and facilities is an important step toward that goal. Having an area marked as partially accessible is not informative or helpful to people with disabilities. For a facility or trail to be accessible, it must comply with all the accessibility guidelines in effect while it is being designed, built, or modified. If a facility or trail does not meet all the requirements to be accessible, it is considered to be not accessible (Zeller et al. 2012). For a project to be considered for the Accessibility co-benefit it should include details about how it may meet said guidelines.

4.2 Aesthetics & Green Space (Mental Health Benefits):

Mental health problems are complex and difficult to handle. Not only do they affect many individuals, but they can have a negative economic cost. According to the paper titled "Doses of Neighborhood Nature: The Benefits for Mental Health of Living with Nature," anxiety and mood disorders are some of the most work-related health issues (Cox et al., 2017). It is in everybody's best interests to improve mental health in any way possible. There are a few theories about how nature helps with mental health. One is that it provides a chance to recover from mental fatigue after a prolonged period of direct attention. Another theory is that natural environments allow for a reduced reaction to stress. Interactions with nature promote psychological restoration, improve mood, improve attention, and reduce stress and anxiety (Cox et al., 2017). For a project to be

considered for the Aesthetics & Green Space co-benefit it must increase green space in some way. This could be by planting trees, or increasing other plant life, etc..

4.3 Increasing Outdoor Recreation Opportunities

According to The Wilderness Society (2021), in 2019 a little over half of Americans participated in outdoor recreation at least once. Activities like biking, sailing, canoeing, kayaking, etc. are beneficial to both one's mental and physical health. Outdoor recreation also provides jobs and generates about 7.8 billion dollars in consumer spending which is beneficial to our economy. Outdoor recreation promotes the economy, individuals, and greater environmental awareness. For a project to be considered for the Outdoor Recreation co-benefit it needs to either add recreational areas like hiking trails and campsites or improve/maintain existing recreational areas.

4.4 Increasing Urban Tree Canopy:

Improving a city's urban tree canopy has many benefits both to the people and the local economy. It can provide wildlife habitat and reduce air temperatures and pollution. It can also increase property values, provide aesthetic benefits, and attract business and residents to the area (USDA Forest Service, 2019). Tree canopy also helps with stormwater management, intercepting rainfall that would otherwise run off the paved roads and into local waters. According to the Center for Watershed Protection, the urban tree canopy only covers about 27% and due to a wide variety of stressors, the trees have shortened lifespans (CWP, 2021). Monitoring and increasing urban tree canopy has positive effects for all involved. The Burlington Parks Department's goal is to increase the urban tree canopy from 43% to 50%, increasing the environmental and aesthetic benefits as well (Burlington Parks and Recreation, n.d.). For a project to be considered for the Increasing Tree Canopy co-benefit, it should incorporate tree planting in urban areas.

5. Education

5.1 Watershed Education and Awareness of Environmental Problems:

The watershed model of education builds an understanding of interdisciplinary problem solving that helps students and community members understand ecological systems and their boundaries (Eaton, 2021). Watershed education, whether it takes the form of interpretive signage, community workshops, or citizen science initiatives, acts as a bridge between researchers and the communities they serve. Educational initiatives put environmental problems in perspective for individuals and explain what actions community members can take to address or mitigate those problems (Watershed Staff, 2017). For a project to be considered for the Watershed Education and Awareness of Environmental Problems co-benefit, it must include a form of outreach that educates the public about watershed health. This may include interpretive signage in natural areas, partnerships with schools, public workshops, or publications.

5.2 Trust Between Communities, Scientists, and Agencies:
Community involvement in watershed health projects encourages multiple ways of thinking about a watershed issue, according to a study examining the benefits of citizen science initiatives. Citizen science projects inform and empower local community members, and they build and demonstrate trust and communication in the local community. In addition, community involvement increases social capital, which is defined as the network of relationships within a community (Walker et al, 2020). For a project to be considered for the Trust Between Communities, Scientists, and Agencies co-benefit, the public must be involved in gathering data, making decisions about the project, and/or implementing the proposed solutions.

6. Economic Growth

6.1 Job Creation, Retention, and Workforce Development:
Creating and upgrading sustainable infrastructure creates jobs in the construction and wastewater sectors. In addition to creating and retaining jobs, it is important that projects contribute to workforce development. A study by FHI 360, a nonprofit focused around human development, determined that workforce development can be measured through many different indicators. This includes job training and education, the number of jobs and duration of jobs created, and potential for advancement (Lindsay & Babb, 2015). For a project to be considered for the Job Creation, Retention, and Workforce Development co-benefit, it must include creation of jobs and/or improvement of jobs through subsidized training or career advancement opportunities.

6.2 Promote Sustainable Energy Practices:
Drinking water and wastewater plants can account for 30 to 40 percent of energy used by municipal governments, and up to 40 percent of wastewater plant costs are associated with energy usage, according to an EPA report. Infrastructure and practices that improve energy efficiency in water treatment plants are essential to improving sustainability and reducing expenses. This is generally accomplished by generating energy on-site (through CHP systems, wind, or solar), buying renewable energy from third-party sources, conducting and using energy audits to improve efficiency, and implementing best energy practices (EPA, 2021). For a project to be considered for the Sustainable Energy Practices co-benefit, it must reduce the amount of energy being used and/or utilize renewable energy sources.

6.3 Carbon Reduction via Green Stormwater Infrastructure:
Green infrastructure to combat high flooding events can be cost effective in the long term while reducing carbon emissions. For example, rain gardens, bioswales, permeable pavement, constructed wetlands, bioretention ponds, green roofs, and rain barrels can be easily implemented for small or large-scale water quality restoration projects (Environmental Protection Agency, 2021). A cost benefit analysis (CBA) is used to determine the efficiency of installing a type of green infrastructure through weighing the benefits (increases in human

well-being) against the costs (reductions in human well-being) through an economic viewpoint. A CBA takes into account environmental, social and public health outcomes from the management approaches. After initial installation costs, these systems ideally accomplish sustainability by running efficiently and effectively with an emphasis on a long term management plan (Changsoon et al., 2021). For a project to be considered for the Carbon Reduction via Green Stormwater Infrastructure co-benefit, it must outline a CBA which includes the resulting tangible and intangible pros/cons of the proposed infrastructure plan.

6.4 Increased Property Values:

Several studies have suggested that water quality affects property values (Bin et al, 2017; Guignet et al, 2019; Wolf & Klaiber, 2017). One long-term study in Ohio examining the effect of cyanobacteria blooms on property values found that capitalization losses for lake-adjacent homes exceeded 22 percent (Wolf & Kaiser, 2017). Multiple studies suggest that the impact of water quality affects property values for both waterfront and non-waterfront homes, though waterfront properties are affected to a greater degree (Guignet et al, 2019; Wolf & Klaiber, 2017). For a project to be considered for the Increased Property Values co-benefit, it must directly address cyanobacterial blooms in a residential area.

Limitations & Future Work

We recognize this list is the first step in creating a holistic framework for assessing water quality restoration projects in Vermont. However, the time and resources granted limited the scope of this project. The following explanations describe limitations and future work that are suggested to allow this project to reach a higher level of potential.

EJ concerns vary by community. Without consensus and input from individuals in the community, frameworks to quantify and rank EJ are incomplete. Obtaining input from every community in VT was outside the scope of this project. Future work should include community input through outreach, surveys, focus groups, individual interviews, and any other related inclusion methods. Although a helpful starting point and planning tool for this project, the VT SVI is limited to the U.S. Census data and estimates (Vermont Department of Health, 2015). Considering that members of a community are more knowledgeable about issues they face than someone from outside of said community, projects should listen to, and respect that knowledge.

For the future, we recommend continuing to develop partnerships with environmental groups to receive their feedback regarding the co-benefits matrix. Groups that were contacted include Watersheds United Vermont, the Lewis Creek Association, and Winooski Natural Resources Conservation District. The feedback received was very valuable, so we suggest sustaining these relationships to further target areas in need of improvement.

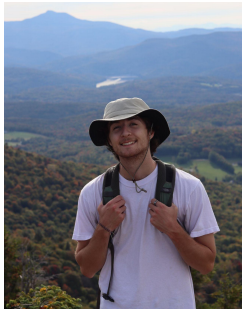
In addition, when testing the efficiency of our matrix by assessing past project proposals, we were unable to send our appendices to outside sources. These contributors may have been able to find areas we overlooked given our extensive research associated with these topics. There might be need for additional information or refinements after the public and councils use these documents.

Another major limitation is that the metrics outlined for certain co-benefits may not be applicable to or included in all of the projects that the document is designed to review. Many co-benefits do not lend themselves to standardized quantitative measurements. Additionally, several past project proposals addressed quantitative co-benefits without providing numeric estimates, which makes assessment more difficult. Further research could determine what metrics would be both effective and applicable in assessing projects.

Acknowledgements

We would like to thank everyone who worked with us and supported us throughout this project. First, thank you to Chris Rottler, Ethan Swift, and Ben Copans from the Vermont Department of Environmental Conservation for providing the framework for this project, meeting with us weekly, suggesting resources for our research, and giving feedback throughout the process. Thank you also to Professor Dave Kestenbaum, and our graduate teaching assistant, Sonya Kaufman, for providing guidance as we worked through the project. Thank you Michael Williamson for proofreading our document and providing feedback on clarity and grammar. To the environmental organizations we contacted, Lyn Munno from Vermont Watersheds United, Kate Kelly from the Lewis Creek Association, Ashley Eaton from Lake Champlain Sea Grant, and Kristen Balschunat from the Winooski Natural Resources Conservation District, we are very thankful for the feedback that helped further our co-benefits list.

About the Authors



Bryce Carleton (*he/him – B.S. in Environmental Science*)

Bryce is a senior at the University of Vermont majoring in Environmental Science and concentrating in Ecological Design. He is from Exeter, New Hampshire. Here at UVM he is on the leadership committee for the Eco-Design Coop, a project-based club that revolves around ecology, design, and circular economy topics. For work, he is the horticulturist who aided in the redo and upkeep of the new and improved Aiken Solarium. He also works in Dr. Hurley's ecological design lab, continuing his summer research and working as a research assistant in ongoing research on bioretention systems. In his free time, he enjoys caring for the Solarium and his own collection of plants.

Sarah Clauss *(she/they – B.S. in Environmental Science)*

Sarah is a senior in RSENR majoring in Environmental Science with a concentration in Water Resources and a minor in Soil Science. She is originally from Shelburne, VT. She is currently conducting a senior thesis study examining the effects of public hiking trail use on sediment deposition in streams. She is also the president of the UVM Summit

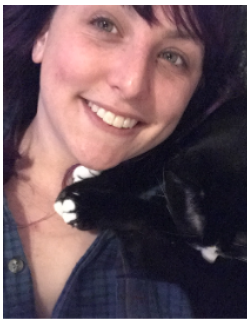
Sisters, a student group devoted to building outdoor skills and connections for female-identifying students. She is passionate about addressing water quality challenges through place-based sustainability education and outreach. In her free time, she enjoys hiking, paddling, camping, and identifying trees.

Tucker Diveley *(he/him- B.S. Environmental Science)*

Tucker is a senior at the University of Vermont majoring in Environmental Science with a concentration in conservation biology. Previously involved with restoration projects at Oakledge Park in Burlington, Vermont doing wetland restoration, and research on native freshwater mollusks in Iowa's great lakes. The passion he has for the environment stems from his love of glaciers and slowing/reversing their melting. Outside of academia he loves to exercise, cook, disc golf and fish. Tucker is originally from Richmond, Virginia.

Jenna Goodman *(she/her- B.S. Environmental Science)*

Jenna is a senior at The University of Vermont majoring in Environmental Science and minoring in Wildlife Biology. She is from Franklin Massachusetts and in her free time she likes to be outside camping, and skiing. In the past she has worked with the Winooski Natural Resources Conservation District, helping to mitigate damage from the invasive Emerald Ash Borer as well as helping local farmers to create nutrient management plans for their land. She is passionate about wildlife and conservation and is hoping to follow that path in her career.



Erica Hirschhorn *(she/her - B.S. Environmental Studies)*

Erica is a senior at the University of Vermont Rubenstein School of Environment and Natural Resources. She is passionate about energy systems, natural resource management, environmental justice and community engagement. Outside of school Erica enjoys hiking, skiing, and observing animal interactions. She lives in Shelburne, VT with her partner and their tuxedo cat.

Charlotte O'Brien *(she/her - B.S. Environmental Science)*

Charlotte is a senior Environmental Science major with a concentration in Ecological Design in the Rubenstein school at the University of Vermont. This project along with her current internship as a Watershed Educator with Lake Champlain Sea Grant, helped develop her passion in watershed education and landscape design mitigation practices. Outside of school, she enjoys kayaking, exploring Burlington, and relaxing in a hammock.

Lindsay VanFossen *(she/her - B.S. Environmental Science)*

Lindsay is a senior at the University of Vermont majoring in Environmental Science with a concentration in Water Resources. She is passionate about watershed sciences, phytoplankton community dynamics, and the outreach associated with them. Currently, she interns with Lake Champlain Sea Grant as a Watershed Educator and is pursuing research in Dr. Morales-Williams limnology lab on lake stratification effects on dominating phytoplankton taxa in Missisquoi Bay. In her free time she enjoys exploring Vermont and photography. Lindsay is originally from Warrington, PA.

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Appendices

Appendix A: Condensed Co-Benefit List

1. Environmental Justice
    - 1.1. Prioritizing Vulnerable Communities
    - 1.2. Involvement of Community Stakeholders
    - 1.3. Honoring Traditional Ecological Knowledge
    - 1.4. Access to Clean Water and Food
    - 1.5. Protecting Sacred Resources and Indigenous Land
2. Clean Water and Sanitation
    - 2.1 Reduction/Treatment of Other Key Pollutants
3. Ecosystem Services and Climate Resiliency
    - 3.1 Carbon Sequestration
    - 3.2 Flood Resiliency and Reduction
    - 3.3 Reduced Runoff and Erosion
    - 3.4 Supporting Native Pollinator Species
    - 3.5 Promoting Biodiversity
    - 3.6 Reduction of Aquatic Invasive Species
    - 3.7 Improving Terrestrial and Aquatic Habitat Connectivity
    - 3.8 Addressing High Risk Areas Due to Past Environmental Degradation
4. Recreation and Community
    - 4.1. Inclusive Accessibility of Natural Areas for Local Communities
    - 4.2. Aesthetics & Green Space (Mental Health Benefits)
    - 4.3. Increasing Outdoor Recreation Opportunities
    - 4.4. Increasing Urban Tree Canopy
5. Education
    - 5.1. Watershed Education and Awareness of Environmental Problems
    - 5.2. Trust Between Communities, Scientists, and Agencies
6. Economic Growth
    - 6.1. Job Creation, Retention, and Workforce Development
    - 6.2. Promote Sustainable Energy Practices
    - 6.3. Carbon Reduction via Green Stormwater Infrastructure
    - 6.4. Increased Property Values

Appendix B: Vermont Social Vulnerability Index Overlay Map

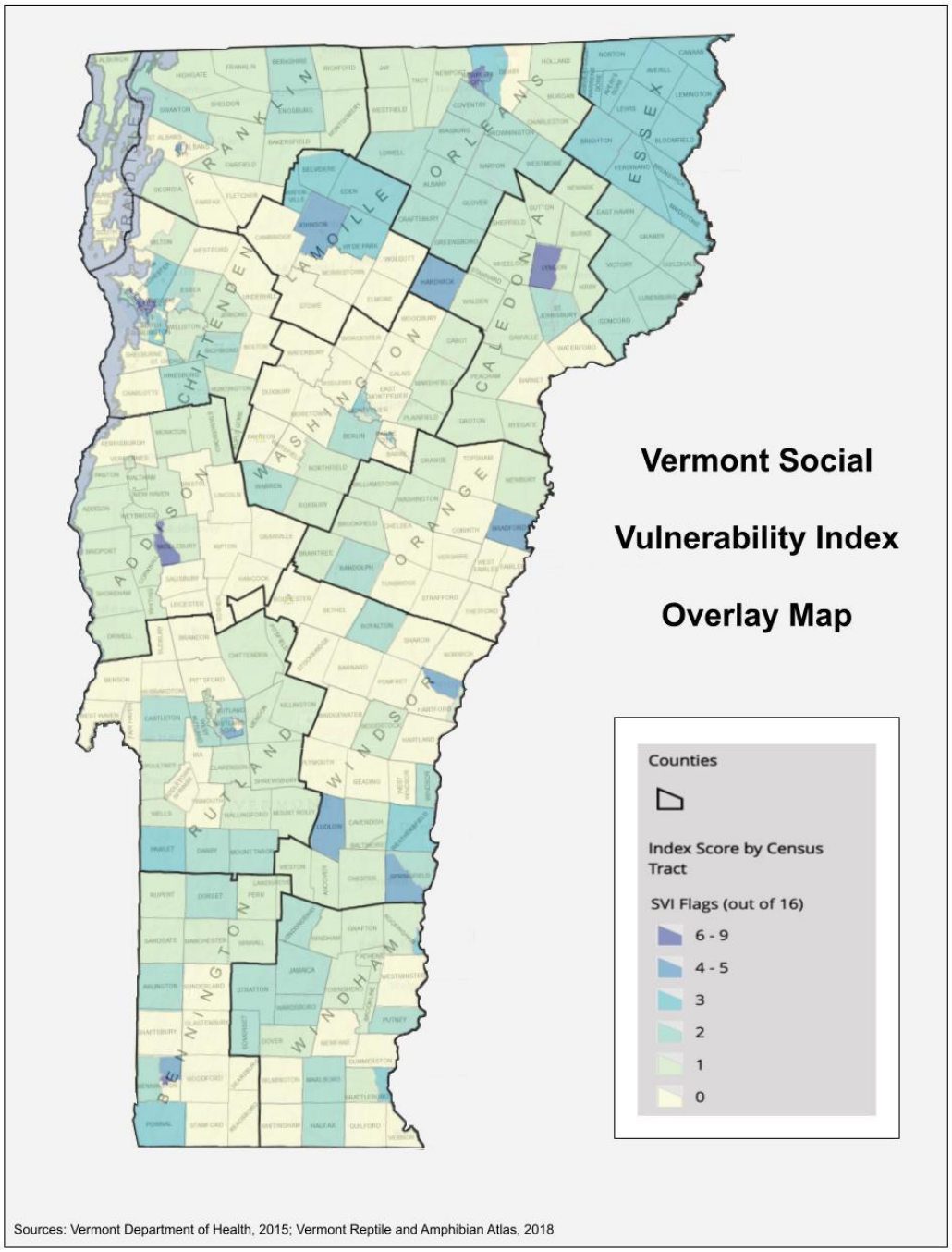

Figure 1. The *Vermont Social Vulnerability Index Overlay Map* uses the Social Vulnerability Index Overview Map (2015) as a basemap, overlaid with the Counties and Towns of Vermont Map (2018), to clearly illustrate municipality boundaries in relation to SVI rankings. Because P removal project proposals generally do not include mention of U.S. Census Tracts, this map may help Basin Water Quality Councils determine whether a proposed project affects a vulnerable area. Overlay map created with Google™ Drawings by Erica Hirchhorn on December 5, 2021. For educational purposes only.

Appendix C: Vulnerable Communities by Social Vulnerability Index Ranking and Presence of 303(d) Priority Waters

Key:		50% or more of SVI flags have high relative standard error
		Census tract with a population of 0

			Number of SVI Flags				Presence of 303(d) Priority Waters		
County	Census Tract	Municipality	Socioeconomic	Demographic	Housing/Transportation	Total Flags	Streams & Rivers	Lakes & Ponds	Watersheds
Addison	9604	Addison	0	1	0	1		X	X
Addison	9609	Bridport	0	1	0	1		X	X
Addison	9605	Bristol	0	0	0	0			X
Addison	9609	Cornwall	0	1	0	1			
Addison	9602	Ferrisburg	0	0	0	0	X	X	X
Addison	9606	Goshen	0	0	0	0			
Addison	9606	Granville	0	0	0	0			X
Addison	9606	Hancock	0	0	0	0			
Addison	9610	Leicester	0	0	0	0			
Addison	9606	Lincoln	0	0	0	0			
Addison	9607	Middlebury	0	1	0	1			
Addison	9608	Middlebury	1	2	3	6			
Addison	9601	Monkton	0	1	0	1			X
Addison	9604	New Haven	0	1	0	1			X
Addison	9609	Orwell	0	1	0	1		X	X
Addison	9604	Panton	0	1	0	1		X	X
Addison	9606	Ripton	0	0	0	0			
Addison	9610	Salisbury	0	0	0	0	X		X
Addison	9609	Shoreham	0	1	0	1		X	X
Addison	9601	Starksboro	0	1	0	1			X
Addison	9603	Vergennes	1	0	0	1	X		X
Addison	9604	Waltham	0	1	0	1			
Addison	9604	Weybridge	0	1	0	1			
Addison	9609	Whiting	0	1	0	1	X		
Bennington	9707	Arlington	1	1	0	2			
Bennington	9709	Bennington	1	2	1	4			
Bennington	9710	Bennington	0	1	1	2			X
Bennington	9711	Bennington	0	0	0	0			X
Bennington	9712	Bennington	4	2	0	6	X		X
Bennington	9702	Dorset	0	2	0	2			X
Bennington	9706	Glastenbury	0	0	0	0	X	X	
Bennington	9705	Landgrove	0	1	0	1			X
Bennington	9704	Manchester	0	1	0	1	X		X
Bennington	9705	Peru	0	1	0	1			X
Bennington	9713	Pownal	1	0	2	3	X		X
Bennington	9706	Readsboro	0	0	0	0			X
Bennington	9703	Rupert	0	1	0	1			X
Bennington	9703	Sandgate	0	1	0	1			
Bennington	9706	Searsburg	0	0	0	0	X		X
Bennington	9708	Shaftsbury	0	0	0	0			
Bennington	9706	Stamford	0	0	0	0			X
Bennington	9706	Sunderland	0	0	0	0	X	X	X
Bennington	9705	Winhall	0	1	0	1			X
Bennington	9706	Woodford	0	0	0	0			X
Caledonia	9579	Barnet	0	0	0	0			X
Caledonia	9571	Burke	0	1	0	1			X
Caledonia	9576	Danville	0	1	0	1			X
Caledonia	9578	Groton	0	1	0	1			X
Caledonia	9577	Hardwick	1	2	1	4			
Caledonia	9571	Kirby	0	1	0	1			X
Caledonia	9572	Lyndon	0	0	1	1			X
Caledonia	9573	Lyndon	3	2	2	7			X
Caledonia	9570	Newark	0	0	1	1			X
Caledonia	9578	Peacham	0	1	0	1			X
Caledonia	9578	Ryegate	0	1	0	1			
Caledonia	9570	Sheffield	0	0	1	1			X
Caledonia	9574	St. Johnsbury	0	1	1	2	X		X
Caledonia	9575	St. Johnsbury	2	0	0	2			X
Caledonia	9570	Stannard	0	0	1	1			X
Caledonia	9570	Sutton	0	0	1	1			X
Caledonia	9570	Walden	0	0	1	1			X
Caledonia	9579	Waterford	0	0	0	0	X		X
Caledonia	9570	Wheelock	0	0	1	1			X

			Number of SVI Flags				Presence of 303(d) Priority Waters		
County	Census Tract	Municipality	Socioeconomic	Demographic	Housing/Transportation	Total Flags	Streams & Rivers	Lakes & Ponds	Watersheds
Essex	9501	Averill	1	2	0	**3**			
Essex	9501	Avery's Gore	1	2	0	**3**			
Essex	9501	Bloomfield	1	2	0	**3**			
Essex	9502	Brighton	2	1	0	**3**			X
Essex	9501	Brunswick	1	2	0	**3**			
Essex	9501	Canaan	1	2	0	**3**			
Essex	9505	Concord	2	0	0	**2**			X
Essex	9505	East Haven	2	0	0	**2**			X
Essex	9501	Ferdinand	1	2	0	**3**		X	X
Essex	9505	Grandby	2	0	0	**2**			X
Essex	9505	Guildhall	2	0	0	**2**			X
Essex	9501	Lemington	1	2	0	**3**			
Essex	9501	Lewis	1	2	0	**3**			
Essex	9505	Lunenburg	2	0	0	**2**			X
Essex	9501	Maidstone	1	2	0	**3**			
Essex	9501	Norton	1	2	0	**3**			
Essex	9505	Victory	2	0	0	**2**			X
Essex	9501	Warner's Grant	1	2	0	**3**			
Essex	9501	Warren Gore	1	2	0	**3**			
Chittenden	29	Bolton	0	0	0	**0**	X		X
Chittenden	35.03	Buel's Gore	0	1	0	**1**			
Chittenden	1	Burlington	0	2	0	**2**	X		X
Chittenden	2	Burlington	0	2	0	**2**		X	X
Chittenden	3	Burlington	4	2	2	**8**	X		X
Chittenden	4	Burlington	4	2	3	**9**			X
Chittenden	5	Burlington	3	2	1	**6**			X
Chittenden	6	Burlington	2	2	2	**6**	X		X
Chittenden	8	Burlington	0	1	0	**1**	X		X
Chittenden	9	Burlington	1	0	3	**4**			X
Chittenden	10	Burlington	1	2	2	**5**	X	X	X
Chittenden	39	Burlington	3	1	1	**5**			X
Chittenden	35.01	Charlotte	0	0	0	**0**			X
Chittenden	22	Colchester	0	1	2	**3**	X	X	X
Chittenden	23.01	Colchester	0	0	0	**0**	X	X	X
Chittenden	23.02	Colchester	0	0	0	**0**	X	X	X
Chittenden	26.01	Essex Junction	0	0	0	**0**			X
Chittenden	26.02	Essex Junction	0	2	0	**2**			X
Chittenden	27.01	Essex	0	2	0	**2**			X
Chittenden	27.02	Essex	0	1	0	**1**			
Chittenden	35.02	Hinesburg	0	1	1	**2**			X
Chittenden	35.03	Huntington	0	1	0	**1**			X
Chittenden	28	Jericho	0	1	0	**1**			
Chittenden	21.01	Milton	0	0	0	**0**		X	X
Chittenden	21.02	Milton	0	0	1	**1**	X		X
Chittenden	30	Richmond	0	1	1	**2**			X
Chittenden	34	Shelburne	0	0	0	**0**	X	X	X
Chittenden	11	South Burlington	0	0	0	**0**	X	X	
Chittenden	33.01	South Burlington	0	3	0	**3**	X		X
Chittenden	33.04	South Burlington	0	0	1	**1**	X	X	X
Chittenden	36	South Burlington	0	1	1	**2**	X		X
Chittenden	40.02	South Burlington	0	2	1	**3**	X		X
Chittenden	9800	South Burlington					X		X
Chittenden	35.02	St. George	0	1	1	**2**			X
Chittenden	29	Underhill	0	0	0	**0**			X
Chittenden	29	Westford	0	0	0	**0**			X
Chittenden	31	Williston	0	1	0	**1**	X		X
Chittenden	25	Winooski	2	2	2	**6**	X		X
Chittenden	24	Winooski	3	3	1	**7**	X		X

			Number of SVI Flags				Presence of 303(d) Priority Waters		
County	Census Tract	Municipality	Socioeconomic	Demographic	Housing/Transportation	Total Flags	Streams & Rivers	Lakes & Ponds	Watersheds
Franklin	104	Bakersfield	0	1	0	**1**			
Franklin	102	Berkshire	1	1	0	**2**	X		X
Franklin	102	Enosburg	1	1	0	**2**	X		X
Franklin	110	Fairfax	0	0	0	**0**			X
Franklin	104	Fairfield	0	1	0	**1**	X		X
Franklin	110	Fletcher	0	0	0	**0**	X	X	X
Franklin	101	Franklin	0	0	1	**1**	X		X
Franklin	109	Georgia	0	1	0	**1**	X	X	X
Franklin	101	Highgate	0	0	1	**1**	X		X
Franklin	103	Montgomery	1	0	0	**1**			
Franklin	103	Richford	1	0	0	**1**	X		X
Franklin	101	Sheldon	0	0	1	**1**	X		X
Franklin	107	St Albans City	1	2	1	**4**	X		X
Franklin	108	St Albans City	0	0	0	**0**			X
Franklin	106	St Albans Town	0	0	0	**0**	X	X	X
Franklin	105	Swanton	1	1	0	**2**	X	X	X
Grand Isle	201	Alburgh	1	0	0	**1**		X	X
Grand Isle	202	Grand Isle	0	0	0	**0**		X	X
Grand Isle	201	Isle La Motte	1	0	0	**1**		X	X
Grand Isle	201	North Hero	1	0	0	**1**		X	X
Grand Isle	202	South Hero	0	0	0	**0**		X	X
Lamoille	103	Belvidere	1	0	0	**1**			
Lamoille	104	Belvidere	0	1	0	**1**			
Lamoille	9530	Belvidere	0	1	2	**3**			
Lamoille	9531	Cambridge	0	0	0	**0**	X		X
Lamoille	9530	Eden	0	1	2	**3**	X		X
Lamoille	9534	Elmore	0	0	0	**0**			X
Lamoille	9533	Hyde Park	1	1	1	**3**			X
Lamoille	9532	Johnson	2	0	2	**4**			
Lamoille	9535	Morristown	0	0	0	**0**	X		X
Lamoille	9536	Stowe	0	0	0	**0**	X		X
Lamoille	9530	Waterville	0	1	2	**3**			
Lamoille	9534	Wolcott	0	0	0	**0**			
Orleans	9517	Albany	1	0	1	**2**			X
Orleans	9518	Barton	1	1	0	**2**	X		X
Orleans	9519	Brownington	1	0	1	**2**			
Orleans	9511	Charleston	1	0	0	**1**			
Orleans	9519	Coventry	1	0	1	**2**		X	X
Orleans	9517	Crafsbury	1	0	1	**2**		X	X
Orleans	9512	Derby	0	0	0	**0**	X		X
Orleans	9513	Derby	1	2	0	**3**			
Orleans	9520	Glover	1	1	0	**2**			X
Orleans	9520	Greensboro	1	1	0	**2**			
Orleans	9511	Holland	1	0	0	**1**	X		X
Orleans	9517	Irasburg	1	0	1	**2**			
Orleans	9516	Jay	1	0	0	**1**	X		X
Orleans	9517	Lowell	1	0	1	**2**	X		X
Orleans	9511	Morgan	1	0	0	**1**			
Orleans	9514	Newport City	2	1	1	**4**			
Orleans	9515	Newport City	4	2	1	**7**			
Orleans	9516	Newport Town	1	0	0	**1**	X		X
Orleans	9516	Troy	1	0	0	**1**	X		X
Orleans	9516	Westfield	1	0	0	**1**	X		X
Orleans	9519	Westmore	1	0	1	**2**			X

			Number of SVI Flags				Presence of 303(d) Priority Waters		
County	Census Tract	Municipality	Socioeconomic	Demographic	Housing/Transportation	Total Flags	Streams & Rivers	Lakes & Ponds	Watersheds
Rutland	9623	Benson	0	0	0	**0**	X	X	X
Rutland	9622	Brandon	0	0	0	**0**			
Rutland	9636	Castleton	1	0	1	**2**			X
Rutland	9621	Chittenden	0	0	1	**1**			X
Rutland	9634	Clarendon	0	0	1	**1**			X
Rutland	9642	Danby	1	0	1	**2**			X
Rutland	9637	Fair Haven	0	0	0	**0**			X
Rutland	9623	Hubbardton	0	0	0	**0**			X
Rutland	9635	Ira	0	0	0	**0**			X
Rutland	9628	Killington	0	0	1	**1**	X		X
Rutland	9628	Mendon	0	0	1	**1**			X
Rutland	9635	Middletown Springs	0	0	0	**0**			
Rutland	9640	Mount Holly	1	0	0	**1**			X
Rutland	9642	Mount Tabor	1	0	1	**2**			X
Rutland	9643	Pawlet	2	1	0	**3**	X		X
Rutland	9621	Pittsfield	0	0	1	**1**			
Rutland	9624	Pittsford	0	0	0	**0**			X
Rutland	9638	Poultney	0	0	1	**1**			X
Rutland	9625	Proctor	0	1	0	**1**			X
Rutland	9630	Rutland City	0	0	0	**0**			X
Rutland	9631	Rutland City	0	1	2	**3**			X
Rutland	9632	Rutland City	0	2	1	**3**	X		X
Rutland	9633	Rutland City	2	0	3	**5**	X		X
Rutland	**9627**	Rutland	1	1	0	**2**			X
Rutland	9628	Shrewsbury	0	0	1	**1**			X
Rutland	9623	Sudbury	0	0	0	**0**	X		X
Rutland	9635	Tinmouth	0	0	0	**0**			X
Rutland	9640	Wallingford	1	0	0	**1**			X
Rutland	9638	Wells	0	0	1	**1**			
Rutland	9623	West Haven	0	0	0	**0**			
Rutland	**9626**	West Rutland	1	1	0	**2**			X
Washington	**9551**	Barre City	0	1	1	**2**	X		X
Washington	**9552**	Barre City	0	0	0	**0**	X		X
Washington	9553	Barre Town	0	0	0	**0**			X
Washington	9554	Barre Town	0	0	0	**0**			X
Washington	9545	Belrlin	0	1	1	**2**	X		X
Washington	9540	Cabot	0	1	0	**1**	X		X
Washington	9541	Calais	0	0	0	**0**			X
Washington	9544	Duxbury	0	0	0	**0**			
Washington	**9550**	East Montpelier	0	0	0	**0**			X
Washington	9558	Fayston	0	0	0	**0**			
Washington	9540	Marshfield	0	1	0	**1**	X		X
Washington	9542	Middlesex	0	0	0	**0**			
Washington	**9546**	Montpelier	1	0	2	**3**	X		X
Washington	9547	Montpelier	0	0	2	**2**	X		X
Washington	9548	Montpelier	0	0	2	**2**	X		X
Washington	9549	Montpelier	0	0	1	**1**	X		X
Washington	9544	Moretown	0	0	0	**0**			
Washington	9555	Northfield	0	0	1	**1**			
Washington	9540	Plainfield	0	1	0	**1**	X		X
Washington	9555	Roxbury	0	0	1	**1**		X	X
Washington	9557	Waitsfield	0	0	0	**0**			
Washington	9556	Warren	0	0	2	**2**	X		X
Washington	9543	Waterbury	0	0	0	**0**		X	X
Washington	9541	Woodbury	0	0	0	**0**			X
Washington	9542	Worcester	0	0	0	**0**			X

			Number of SVI Flags				Presence of 303(d) Priority Waters		
County	Census Tract	Municipality	Socioeconomic	Demographic	Housing/Transportation	Total Flags	Streams & Rivers	Lakes & Ponds	Watersheds
Windham	9672	Athens	0	1	0	1			
Windham	9684	Brattleboro	0	1	0	1			
Windham	9685	Brattleboro	2	0	1	3			
Windham	9686	Brattleboro	0	1	2	3	X		X
Windham	9672	Brookline	0	1	0	1			
Windham	9679	Dover	1	0	0	1	X		X
Windham	9683	Dummerston	0	0	0	0			X
Windham	9672	Grafton	0	1	0	1			
Windham	9687	Guilford	0	0	0	0			
Windham	9682	Halifax	1	0	1	2			
Windham	9674	Jamaica	1	1	0	2	X		X
Windham	9673	Londonderry	1	1	0	2			X
Windham	9682	Marlboro	1	0	1	2			
Windham	9678	Newfane	0	0	0	0			
Windham	9677	Putney	0	1	1	2			
Windham	9670	Rockingham	1	2	0	3			
Windham	9671	Rockingham	0	1	0	1	X		X
Windham	9675	Somerset	1	0	1	2	X		X
Windham	9675	Stratton	1	0	1	2	X		X
Windham	9672	Townshend	0	1	0	1	X		X
Windham	9687	Vernon	0	0	0	0	X		X
Windham	9675	Wardsboro	1	0	1	2			X
Windham	9676	Westminster	0	0	0	0			
Windham	9681	Whitingham	0	0	0	0			
Windham	9680	Wilmington	0	0	0	0	X		X
Windham	9672	Windham	0	1	0	1			X
Windsor	9665	Andover	1	0	0	1			X
Windsor	9662	Baltimore	0	0	1	1			X
Windsor	9654	Barnard	0	0	0	0			
Windsor	9652	Bethel	0	0	0	0	X		X
Windsor	9659	Bridgewater	0	0	0	0	X		X
Windsor	9662	Cavendish	0	0	1	1			X
Windsor	9665	Chester	1	0	0	1			X
Windsor	9655.01	Hartford	0	0	0	0			X
Windsor	9655.02	Hartford	1	2	1	4			
Windsor	9656	Hartford	0	1	0	1	X		X
Windsor	9657	Hartland	0	0	0	0			
Windsor	9663	Ludlow	1	2	1	4			X
Windsor	9650	Norwich	0	0	0	0			
Windsor	9659	Plymouth	0	0	0	0			X
Windsor	9654	Pomfret	0	0	0	0			
Windsor	9659	Reading	0	0	0	0			X
Windsor	9652	Rochester	0	0	0	0			
Windsor	9653	Rochester	2	3	2	7			X
Windsor	9651	Royalton	1	0	1	2	X		X
Windsor	9654	Sharon	0	0	0	0			
Windsor	9666	Springfield	1	2	1	4			X
Windsor	9667	Springfield	1	0	1	2			X
Windsor	9654	Stockbridge	0	0	0	0			
Windsor	9661	Weathersfield	1	1	1	3			X
Windsor	9659	West Windsor	0	0	0	0			X
Windsor	9665	Weston	1	0	0	1			X
Windsor	9660	Windsor	0	1	1	2			
Windsor	9658	Woodstock	0	1	0	1			